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Ammoniacal Nitrogen and COD Removal Using Zeolite-Feldspar Mineral Composite Adsorbent

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ABSTARCT : The vigorous combination of waste in landfill recognized as potential hazard source, but one distinctive problem associated with landfill is leachate. Zeolite is well known as good adsorbent but the cost is relatively high. Meanwhile, feldspar is the most abundant mineral group in the world, forming around 60% of the earth's crust. Due to its availability, feldspar becomes one of low cost materials. The combination of feldspar and zeolite are believed to produce inexpensive and suitable composite to treat leachate. The experiment carried out in a series of 250 mL conical flask with varied amount of composite ratio. It shaken for 5 hours with 200 rpm at pH 7. The optimum ratio of feldspar and zeolite chosen is 1:1. The value of the removal percentage of COD and NH_3-N is 49% and 45% respectively and the uptake capacity for both contaminant is 50.14 mg/g and 8.06mg/g respectively. The presence of low cost material like feldspar in the composite has help reduce treatment cost and also help enhance the adsorption capacity.

Keywords: Zeolite, Feldspar, Composite, Adsorbent

1. Introduction

Nowadays, the growth of population contributes to the increasing of industrial and commercial growth in most countries. The growth has been affected the increases of municipal solid waste (MSW) generations. Municipal solid waste is a diverse waste, generated from different sources (that is, residential, commercial, municipal services, agriculture), where each of which is itself heterogeneous [1]. The percentage of solid waste composition is varies for each areas and up to 95% of generated solid waste is currently disposed in landfill [2]. Landfilling has become one of prominent options for disposal and management of solid waste because this alternative offer dumping high quantities of MSW at economical cost compared to other disposal method [3]. However, the production of highly contaminated leachate is a major drawback of this method[4].

Leachate is a high strength wastewater which has been recognized as one of the most concerned pollution sources. Landfill leachate is the hazardous and heavily polluted wastewater, formed as a result of percolation of rainwater and moisture through solid waste in the landfill site. Landfill leachate contain high load of organic matter, high content ammonia nitrogen, heavy metals, inorganic salts and chlorinated organic [5]. The contamination of untreated landfill leachate is one of potential source to effect environment especially soil, surface and groundwater.

Leachate treatment is very complicated, expensive and generally requires multiple process [2]. Over the past 20 years (1983-2005), numerous research studies have been carried out worldwide in the treatment of leachate using various types of individual and/or combined treatment technologies such as physico-chemical and/or combined physico-chemical and biological [4]. In recent years, physico-chemical treatment in landfill leachate has gained great interest. Several technologies such as chemical precipitation, reverse osmosis, ion exchange, membrane filtration, oxidation, air stripping and adsorption have been applied in landfill leachate treatment [2]. Recently application of several indigenous and low cost materials such as palm ash [6], zeolite [7] and limestone [8] in wastewater treatment, particularly as adsorbent is gained many interest [9].

Geological material such as minerals, clay and sandstone is being used as low-cost adsorbents for water and wastewater treatment due to its availability in local places and environmentally friendly materials. Among this mineral, feldspar is the most abundant mineral group in the world, forming around 60% of the earth's crust and is found in igneous, metamorphic and sedimentary deposits in most countries [10]. Due to the characteristics and the potential absorptive ability of feldspar, feldspars are involved in inexpensive and environmental processes and especially in removing ionic pollutants from water and wastewater [11]. Previous study on felspar as adsorbent show feldspar can remove heavy metal and color in water and wastewater treatment [10].

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Beside, zeolite is naturally hydrated aluminosillicate mineral that belongs to mineral class "tectosillicates". The framework structure of zeolite, alkali or alkaline-earth cations are reversibly fixed in the cavities and can easily be exchanged by surrounding positive ions like Na+, K+, Ca2+, Mg2+ [12]. In contrast to the aluminium and silicone structure atoms, which are mutually bound by chemical (covalent) bonds over common oxygen atoms, cations are bound by the alumosilicate structure mainly by weaker electrostatic bonds, which cause their mobility and capability of being exchanged with solution cations [13]. It make zeolite a material that can remove heavy metal and also ammonium ion [14].

Halim et al, 2008 has stated that a composite material is developed to improve adsorption properties. This study has combined two types of minerals to improve the adsorption properties and reducing costs by replacing part of zolite with feldspar. The effect of zeolite and feldspar ratio toward COD and NH_3-N removal is investigated through this study.

2. Materials and Methods

2.1 Leachate Characteristic

A raw leachate sample was taken from SRLS in Johor and stored according to the Standard Methods for the Examination of Water and Wastewater [15]. Leachate samples were taken from landfill sites and placed in clean airtight HDPE ('high density polyethylene") container. Once the leachate samples arrived at the laboratory, the leachate was stored at 4ºC to minimize any further change that might occur in physiochemical and biological properties until the experiments analyses were carried out later. All chemical analysis was performed within 48h.

2.2 Media.

Feldspar and Natural zeolite used in this study were purchased from CCS Corporation and PT. Anugerah Alam Sdn. Bhd respectively. Both feldspar and zeolite were sieved to obtained 1.18-2.36mm particle size. Then, both media were rinsed and dried in an oven at 100 ± 5^0C for 24 hours.

Prior to the experiment, chemical composition of Feldspar and Zeolite were determined by by X-Ray Fluorescence (XRF) instrument. Table 1 and 2 show the properties of Feldspar and Zeolite respectively

2.3 Optimum Ratio

The determination of the ratio between Feldspar and Zeolite was based on the ammoniacal nitrogen and COD removal. The experiment carried out in a series of 250 mL conical flask with varied amount of media ratio (measured in terms of volume, 40 cm^3) as shown in Table 3. Each of conical flask will be added with 100 mL of leachate and will shake for 5 hours with 200 rpm shaking speed and at pH 7 [16]. The optimum ratio is the ratio that achieves the maximum removal of for COD and NH_3-N

Table 1 Feldspar properties

Properties	
Particle Size(mm)	1.16-2.36
pH	8.62-9.07
SiO_2	53.9%
C	11.0%
AL_2O_3	15.6%
K_2O	10.12%
CaO	0.45%
Fe_2O_3	0.96%
Na_2O	2.84%
MgO	0.19%
Cr_2O_3	0.19%

Table 2 Zeolite properties

Properties	
Particle Size(mm)	1.16-2.36
pH	7.33-8.48
SiO_2	65.06%
C	12.1%
AL_2O_3	10.23%
K_2O	4.18%
CaO	2.77%
Fe_2O_3	1.34%
Na_2O	0.74%
MgO	0.61%
SrO	1.9%

Table 3 Zeolite and feldspar ratio

Sample no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Feldspar (cm^3)	40	35	30	25	20	15	10	5	0
Zeolite (cm^3)	0	5	10	15	20	25	30	35	40

2.4 Analysis Method

COD analyses are performed in accordance to the standard methods described [15] with the use of DR 5000 spectrophotometer. Meanwhile ammoniacal nitrogen was determined by Nessler's method, using HACH spectrophotometer, DR5000

3 . Results and Discussion

3.1 Leachate Characteristic Analysis

The determination of leachate characteristic acted as indicator to determine the level of leachate stability which is importance to decide the most applicable treatment method. Table 4 shows the characteristic of Simpang Renggam Landfill site raw leachate. The characteristic of Simpang Renggam Landfill site raw leachate show the average value of COD and BOD is 9811mg/L and 937 mg/L respectively. Thus, the ratio of

BOD_5 / COD is 0.095, which is less than 0.1. Meanwhile, the ammoniacal nitrogen show high value [17]. Thus, it's indicate that the leachate is a stabilize leachate. Thus, physico-chemical treatment like adsorption is suitable method to applied [18].

Table 4 Simpang Renggam Landfill Site Leachate characteristic

Parameter	Average	Regulation 2009 (Pu(A) 433)
pH	8.65	6-9
Temperature	24	40
Suspended solid(mg/L)	658	50
Ammoniacal nitrogen (mg/L)	1808	5
COD(mg/L)	9811	400
BOD_5*	937	20
BOD_5/COD	0.095	-
Iron(mg/L)	15.82	5.0

3.2 Optimum Ratio of Composite

The determinations of adsorption media composition were based on the highest removal of COD and ammoniacal nitrogen. The ratio of feldspar and zeolite that give maximum removal of for COD and NH_3-N is 20:20 where the removal percentage of COD and NH_3-N is 49% and 45% respectively. Figure 1 and 2 show the result of the effect of different ratio of media towards adsorption properties.

Natural zeolite is known as highly porous material that contributed to adsoption capacity. It also has a natural negative charge or spececifically alkali or alkaline earth cations that are easily exchanged by surrounding positive ion which gives it the remove cations like ammonium (NH^{+4}) as ion exchanger [19,20]. Fortunately, feldspar also has almost similar properties makeit a suitable substitute

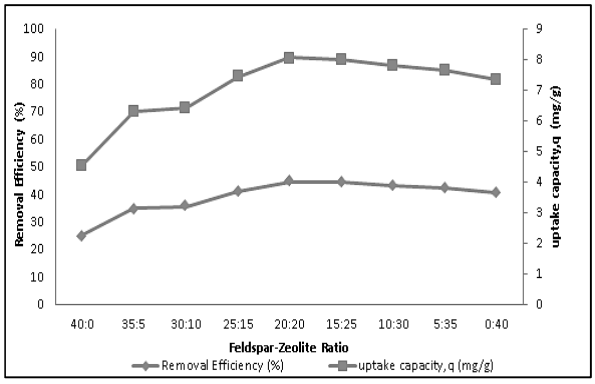

Fig. 1 The optimum ratio of Feldspar-Zeolite for COD removal at pH 7 and 200 rpm shaking speed

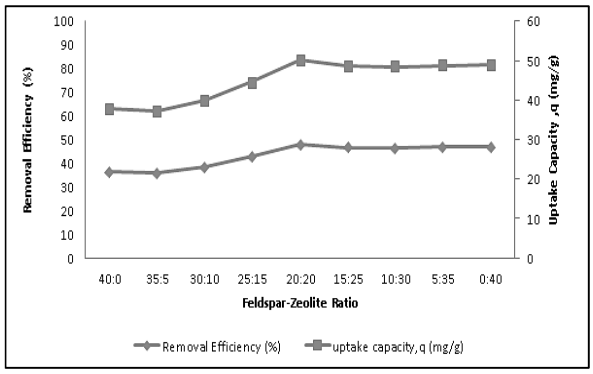

Fig. 2 The optimum ratio of Feldspar-Zeolite for NH_3-N removal at pH 7 and 200 rpm shaking speed

4.0 Conclusions

A composite had been produced using feldspar and zeolite with feldspar as alternative adsorbent media to replace a part of zeolite. The optimum ratio of feldspar and zeolite obtained is 20:20. With this ratio, the composite managed to remove 49% of COD and 45% of NH_3-N, which is higher compared to other ratios but almost as good as zeolite without feldspar. Furthermore, the cost for feldspar is more than cheaper than zeolite. Therefore, with replacing 50% (based on 20:20 ratio) of zeolite, it can reduce more than 50% treatment cost and indirectly produce effective but inexpensive adsorbent.

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